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spark ignition in a cylinder and the auxiliary fuel injection occurs in a cylinder in a predetermined period to increase concentration of carbon monoxide and hydrocarbon in the exhaust gas, and a cylinder having no auxiliary fuel injection is operated with lean mixture and supplies surplus oxygen to the exhaust gas.

REMARKS

The objections to the drawings, abstract, specification and claims are deemed fully addressed by the above amendments thereto, as well as the attached Letter proposing a drawing change.

The Examiner is thanked for noting the informalities. If any further informalities come to the Examiner's attention, we would appreciate notification of same so that the record can be corrected.

The rejections of Claims 7-9 as being anticipated by Hirota et al. ('374) and of Claims 7 and 10 as being anticipated by Hirota ('338), both under 35 USC § 102(e), are traversed, and reconsideration is requested.

The exhaust system, which includes the catalytic converter, of the present invention is provided with carbon monoxide and hydrocarbon periodically from a cylinder in which auxiliary fuel injection occurs, and with surplus oxygen from the cylinders in lean mixture operation. A rapid temperature rise of the catalytic converter is brought about by reaction heat generated by oxidation of the carbon monoxide and hydrocarbon in the exhaust system including the catalytic converter. The time of the temperature rise of the catalytic converter from the inactivated state (200°C or lower) to the activated state (around 300°C or higher) can be shortened so as to reduce exhaust emission components from the exhaust

system in the cold temperature condition of the engine after the starting. Furthermore, the present invention obviates the need for complicated engine ignition control in the temperature rise control.

The Hirota et al. ('374) patent discloses an emission control device of an engine wherein a primary fuel injection and an auxiliary fuel injection are made in a cylinder. The auxiliary fuel injection is made for the purpose of providing carbon monoxide and hydrocarbon as a reducing agent for NOx to an NOx catalyst and also as a reducing agent for sulfate (SO_3 and H_2SO_4) in the catalyst to convert to SO_2. The auxiliary fuel injection is conducted at a high temperature condition such as 500°C or higher of catalyst.

The Hirota et al. ('374) patent also teaches that when the catalyst temperature is lower than such high temperature, the temperature of the catalyst is increased by an auxiliary fuel injection increasing fuel amount in the combustion chamber. Auxiliary fuel injection is thus different between the present invention and the Hirota et al. ('374) patent. In the present invention, the auxiliary fuel injection operation is done for increasing concentration of carbon monoxide and hydrocarbon in the exhaust gas for generating reaction heat in the exhaust system. In the Hirota et al. ('374) patent, however, the auxiliary fuel injection increases flame volume in the cylinder for increasing exhaust temperature.

The Hirota et al. ('338) patent discloses an emission control device of an engine having an exhaust gas purifying catalyst with an electric heater. The temperature of exhaust gas purifying catalyst is controlled by the heater, wherein NOx is adsorbed by the catalyst in low temperature of the catalyst, and

NOx is purged from the catalyst in high temperature of the catalyst. The Hirota et al. ('338) patent also uses auxiliary fuel injection for providing the catalyst with hydrocarbon as a reducing agent for NOx. The catalyst temperature control and the auxiliary fuel injection in the Hirota et al. ('338) patent are not effected in cold state after start of the engine for heating up the catalyst, but in a hot state of the catalyst.

Accordingly, the features added to Claim 7, support for which is found in the Specification at page 7, line 28-page 8, line 10; page 20, line 23-page 21, line 12 and Figs. 15-18, are nowhere suggested in the prior art.

Accordingly, reconsideration and favorable action are earnestly solicited.

If there are any questions regarding this amendment or the application in general, a telephone call to the undersigned would be appreciated since this should expedite the prosecution of the application for all concerned.

If necessary to effect a timely response, this paper should be considered as a petition for an Extension of Time sufficient to effect a timely response, and please charge any deficiency in fees or credit any overpayments to Deposit Account No. 05-1323 (Docket #381AS/49702DV).

Respectfully submitted,

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VERSION WITH MARKINGS TO SHOW CHANGES

IN THE SPECIFICATION:

Page 4, lines 9-14:

The present invention has been worked out for solving the problems set forth above. It is therefore an object of the present invention to quicken activation of catalytic converter by controlling an exhaust gas energy (exhaust temperature) and a combustible component of the exhaust gas (HC, [Co] CO or the like).

Page 6, lines 16-22:

According to the eighth aspect of the invention, an exhaust control system includes a catalytic converter temperature measuring means for measuring a temperature of the catalytic converter for retarding timing of the auxiliary injection when the temperature of the catalytic converter is [high] higher than the predetermined value.

Page 6, line 23 to Page 7, line 5:

According to the ninth aspect of the invention, an exhaust control system for a cylinder fuel injection engine having a cylinder injection injectors directly injecting a fuel into combustion chambers and a catalytic converter provided in an exhaust passage from the combustion chambers for purifying an exhaust gas, wherein catalytic converter temperature measuring means for measuring a temperature of the catalytic converter for periodically inhibiting ignition when the temperature of the catalytic converter is [high] higher than the predetermined value.

Page 7, line 12 to Page 8, line 12:

Namely, in the present invention according to the first to third aspects, HC and CO discharged in the rich mixture operation is purified by oxygen discharged in the lean mixture operation, and the exhaust temperature will not be lowered since rich mixture operation is performed. Also, even when the catalytic converter temperature is low and [this] the reaction amount of the catalytic converter is small, discharge of HC and CO to the atmosphere without reaction can be successfully prevented. Also, when the temperature of the catalytic converter is high and thus HC and CO react, the temperature of the catalytic converter can be further elevated. In the fourth aspect of the present invention, utilizing heat (reaction heat) generated by reaction of CO on the catalytic converter, temperature of the catalytic converter can be elevated. Sixth to eighth aspects of the invention, since [complicate] <u>complicated</u> torque compensation by the ignition timing control is not required. By auxiliary injection, even when temperature of the exhaust gas and the catalytic converter is low and reaction amount of the catalytic converter is small, discharge of HC and CO to the atmosphere without reaction can be successfully prevented. Also, when the temperature of the catalytic converter is high and thus HC and CO react, the temperature of the catalytic converter can be further elevated. In the ninth aspect of the invention, the catalytic converter can be activated by burring HC in the catalytic converter.

Page 11, line 11 to Page 12, line 27:

Fig. 1 is a schematic block diagram showing an exhaust control system of a cylinder fuel injection engine according to the present invention. The exhaust control system generally divided into a fuel system control unit, an air system control unit and an ignition system control unit. At first, discussion of the fuel type control unit will be given along flow of a fuel. A fuel delivered from a fuel tank 5 by a fuel pump 4 is directly injected into a combustion chamber through a valve of a cylinder injection injector 6. By the fuel system control unit, a feeding pressure of the fuel pump 4 and an injection valve of the injector 6 are controlled. Next, the air system control unit will be discussed. An air is sucked into the combustion chamber by a negative pressure generated during downward stroke of a piston 8. An amount of the air to be sucked at this time is variable depending upon throttling by an electrically controlled throttle valve 3 and timings of an intake valve 12 and an exhaust valve 13. Accordingly, in the air system control unit, an open degree of the electrically controlled throttle valve 3 and timings of the suction valve 12 and the exhaust valve 13 are controlled. Finally, the ignition system control unit will be discussed. In the ignition system, a combustible mixture of the combustion chamber is burned by spark ignition from an ignition plug 7. Accordingly, the ignition timing of the ignition plug 7 is controlled by the ignition system control unit. It should be noted that the reference numerals 1, 2, 9 [and] 10, and 11 of Fig. 1 denote an electronic control unit, an air flow meter measuring an intake air flow rate, and air/fuel ratio sensor [and] , a catalyst temperature sensor and a catalyst portion. The following discussion will be given in terms of four cylinder engine illustrated in

Fig. 2. In Fig. 2, the air introduced through the throttle valve (not shown) is distributed to the combustion chambers 16 by induction pipes [4] 14 and is mixed with fuel injected from cylinder injector 15. Exhaust gas after combustion is discharged to the atmosphere through the catalytic converter 19 mounted in the exhaust pipe 18. In Fig. 2, #1, #2, #3 and #4 represent combustion chamber (cylinder) number, respectively. In the embodiment, ignition is performed in order of #1, #3, #4, #2. The reference numeral 17 denotes an engine block.

Page 15, line 16 to Page 17, line 1:

The second embodiment of the present invention will be discussed with reference to the flowchart in Fig. 7. At step S11, measurement of a temperature of a catalytic converter is performed. At step S12, when the temperature of the catalytic converter is higher than a predetermined temperature, the process is advanced to step S18 to set a rich period at TH. Conversely, when the temperature of the catalytic converter is lower than or equal to the predetermined temperature, the process is advanced to step S13 to set the rich period at TL (wherein TL > TH). Next, at step S14, check is performed whether the rich period is modified or not. If the rich period is modified, the process is advanced to step S19 to activate a timer. At step S15, check is performed if the value of the timer is longer than or equal to the rich period or not. If the value of the timer is longer than the rich period, the process is advanced to step S16 to perform rich mixture operation. Thereafter, at step S17, the timer is re-started (the value of the timer is cleared to zero). On the other hand, when the value of the timer as checked at step S15 is shorter than the rich period, the process is

advanced to step S20 to perform lean mixture operation. Fig. 8 shows a result of rich mixture operation and lean mixture operation according to the flowchart of Fig. 7. As shown in Fig. 8, when the temperature of the catalytic converter is lower than the predetermined temperature (low temperature), a period of the cylinder to perform rich mixture operation (rich period) is set to be longer than that when the temperature of the catalytic converter is higher than the predetermined temperature (high temperature). By varying the rich period as set forth above, even when the temperature of the catalytic converter is low and thus reaction amount of the catalytic converter is small, discharge of HC or CO not purified by the catalytic converter [from being discharged] to the atmosphere <u>is minimized</u>. On the other hand when the temperature of the catalytic converter is high to react with HC or CO, amount of HC or CO is increased to increase reaction amount of the catalytic converter to further elevate the temperature of the catalytic converter.

Page 19, line 21 to Page 20, line 2:

On the other hand, when the temperature of the catalytic converter is higher than the predetermined temperature, HC also cause reaction. Reaction heat of HC is higher than reaction heat of CO. Therefore, as shown in Fig. 14B, <u>when</u> the temperature of the catalytic converter [is] <u>becomes</u> higher than the predetermined temperature, it is preferably to increase HC rather than CO. Furthermore, it is preferred to make the air/fuel ratio at the inlet of the catalytic converter lean.

Page 21, lines 4-11:

It should be noted that, in the [shown] embodiment <u>of Fig. 18</u>, since there are cylinders not performing auxiliary injection, the fuel injected by the auxiliary injection can be sufficiently reacted with oxygen. Also, the rich mixture operation by the auxiliary injection has little influence for the engine torque. Therefore, [complicate] <u>complicated</u> torque compensation by ignition timing control is not necessary.

Page 21, line 12 to Page 22, line 8:

The sixth embodiment of the present invention will be discussed with reference to the flowchart shown in Fig. 19. At step S51, the temperature of the catalytic converter is measured. At step S52, when the measured temperature is higher than the predetermined temperature, the process I advanced to step S58 to set the auxiliary injection period at THH. Conversely, when the measured temperature is lower than or equal to the predetermined value, the process is advanced to step S53 to set the auxiliary injection period at TLL (wherein TLL > THH). Next, at step S54, check is performed whether the auxiliary injection period is modified or not. If modified, the process is advanced to step S59 for starting the timer. At step S55, check is performed whether the value of the timer is longer than the auxiliary injection period or not. If the value of the timer is greater than or equal to the auxiliary injection period, the process is advanced to step S57 to re-start the timer (reset the value of the timer to zero). On the other hand, at step S55, if the value of the timer is smaller than the auxiliary injection period, the process is advanced to step S60 to inhibit auxiliary

injection. Otherwise, the process is advanced to step S56 to permit auxiliary injection. Figs. 20A and 20B are timing charts of fuel injection signal in the shown embodiment.

Page 22, lines 9-23:

The seventh embodiment of the present invention will be discussed with reference to the flowchart of Fig. 21. At first, the temperature of the catalytic converter is measured at step S71. If the temperature of the catalytic converter is higher than the predetermined temperature as determined at step S72, the process is advanced to step S74 to set a fuel amount for auxiliary injection 2. On the other hand, if the temperature of the catalytic converter is lower than or equal to the predetermined temperature, the process is advanced to step S73 to set a fuel amount for auxiliary injection 1. As shown in Figs. 22A and 22B, in the auxiliary injection 1 and auxiliary injection 2, injection pulse width is set to be shorter at lower temperature (Fig. 22A) than that at higher temperature (Fig. 22B).

IN THE CLAIMS: (claim 7)

An exhaust control system for a cylinder fuel injection engine [having a] comprising cylinder injection injectors for directly injecting [a] fuel into combustion chambers, and a catalytic converter provided in an exhaust passage from said combustion chambers for purifying an exhaust gas, wherein at least one time of auxiliary fuel injection is performed at a timing from expansion stroke to exhaust [stoke] stroke after a primary injection [injecting] in which a

primary fuel is injected for obtaining an output of the engine, the primary fuel injection occurring before a timing of a spark ignition in a cylinder and the auxiliary fuel injection occurs in a cylinder in a predetermined period to increase concentration of carbon monoxide and hydrocarbon in the exhaust gas, and a cylinder having no auxiliary fuel injection is operated with lean mixture and supplies surplus oxygen to the exhaust gas.